PUBLIC ROADS

A JOURNAL OF HIGHWAY RESEARCH

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

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A VERMONT GRAVEL ROAD

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DIGEST OF VERMONT HIGHWAY TRANSPORTATION SURVEY[1]

Reported by J. GORDON McKAY, Chief of the Division of Highway Economics, United States Bureau of Public Roads

THE State Highway Department of Vermont was established in 1898 to act in an advisory capacity to the towns. In 1906 the principle of State aid was adopted and the State highway department was authorized to assume the supervision of the construction and maintenance of the main thoroughfares upon which State funds were expended in conjunction with funds of the towns.[2]

From 1906 to 1923 the State-aid system was improved almost exclusively with gravel surfaces. Between 1923 and 1926, besides adding to the mileage of gravel roads, the surfaces of this type on the more heavily traveled routes have been surface-treated, and 36 miles of surfaces superior to gravel have been constructed.

The rapid increase in traffic on the principal highways during the past few years has materially increased the cost of maintaining gravel surfaces on these routes; and in 1925 the maintenance of roads and bridges accounted for approximately 53 per cent of the total expenditure on the State-aid system.

The principal highway problems now confronting the State are the construction of surfaces superior to gravel on the principal routes, replacing the present gravel sections upon which the maintenance has become too expensive; the construction of adequate bridges on these routes to replace the remaining old, inferior structures; the establishment of a primary highway system, including the principal routes, for which the State will accept the full responsibility of financing, construction, and maintenance; and the establishment of a secondary system of highways, including routes supplementary to the primary system to be developed under the control of the State on the State-aid principle in cooperation with the towns.

Recognizing the need for a definite program of highway improvement in accordance with the present and expected future traffic importance of the various sections of State highways, the Vermont Highway Board entered into an agreement with the United States Bureau of Public Roads to conduct a cooperative survey of transportation on the highways of the State.

DETAILED TRAFFIC DATA SECURED

The survey was begun on July 16, 1926, and continued for a period of three months.

During this period traffic data were recorded on two days each month at 149 points on the Vermont highways. Each operation consisted of a 10-hour observation period alternating between 6 a. m. to 4 p. m. and 10 a. m. to 8 p. m. Special observers tabulated traffic between 8 p. m. and 6 a. m. Complete 24-hour observations also were made to serve as the basis of a computation of hourly variation in traffic and of average daily traffic; and finally, traffic observations for one-week periods were also made at selected stations to determine variations in traffic by days of the week.

The data obtained at each of the observation points included counts of passenger cars, motor trucks, motor buses, horse-drawn vehicles and vehicles carrying foreign (extra-State) registration tags. Detailed motor-truck and passenger-car data were also recorded at each station, the former including the capacity of the truck, State of registration, place of ownership, origin and destination of trip, type of origin and destination, commodity carried, and tire equipment. Gross and rear-axle weights of trucks were also measured by means of portable scales. Passenger-car data included State of registration, place of ownership, purpose of trip, origin, destination, and number of passengers.

Traffic was observed on all sections of the more important traffic routes, including practically all the numbered routes and many other State-aid roads and on representative sections of the town roads. Stations were located so as to enable close observation of variations in traffic on the several routes and sections of routes.

INTERVIEWING THE DRIVER OF A GROCERY TRUCK AT A WEIGHING STATION

DENSITY OF TRAFFIC ON ALL IMPORTANT ROUTES DETERMINED

There are 14,900 miles of highway in Vermont, of which 14,582 miles are open to public travel. Of this mileage 4,462 miles have been selected as the more important highways in each town and are known as State-aid roads, the remaining 10,120 miles being town roads.

Of the 4,462 miles of State-aid roads 1,968 miles have been numbered and marked by the State highway department. These include the more important of the State-aid roads; and the Federal-aid highway system of 1,043 miles includes the more important of the numbered routes.

This classification of Vermont highways is used throughout the report and the several classes are referred to invariably by the following names:

Federal-aid system, 1,043 miles.

Numbered State-aid routes (including all numbered State-aid routes other than the Federal-aid routes), 925 miles.

Unnumbered State-aid routes (including all State-aid roads which have not been numbered by the State highway department), 2,494 miles.

Town roads, 10,120 miles.

[1] This survey was conducted cooperatively by the Bureau of Public Roads of the U. S. Department of Agriculture and the Vermont State Highway Department. A copy of the full report may be obtained by addressing the Bureau of Public Roads.

[2] The town is the local unit of government in Vermont.

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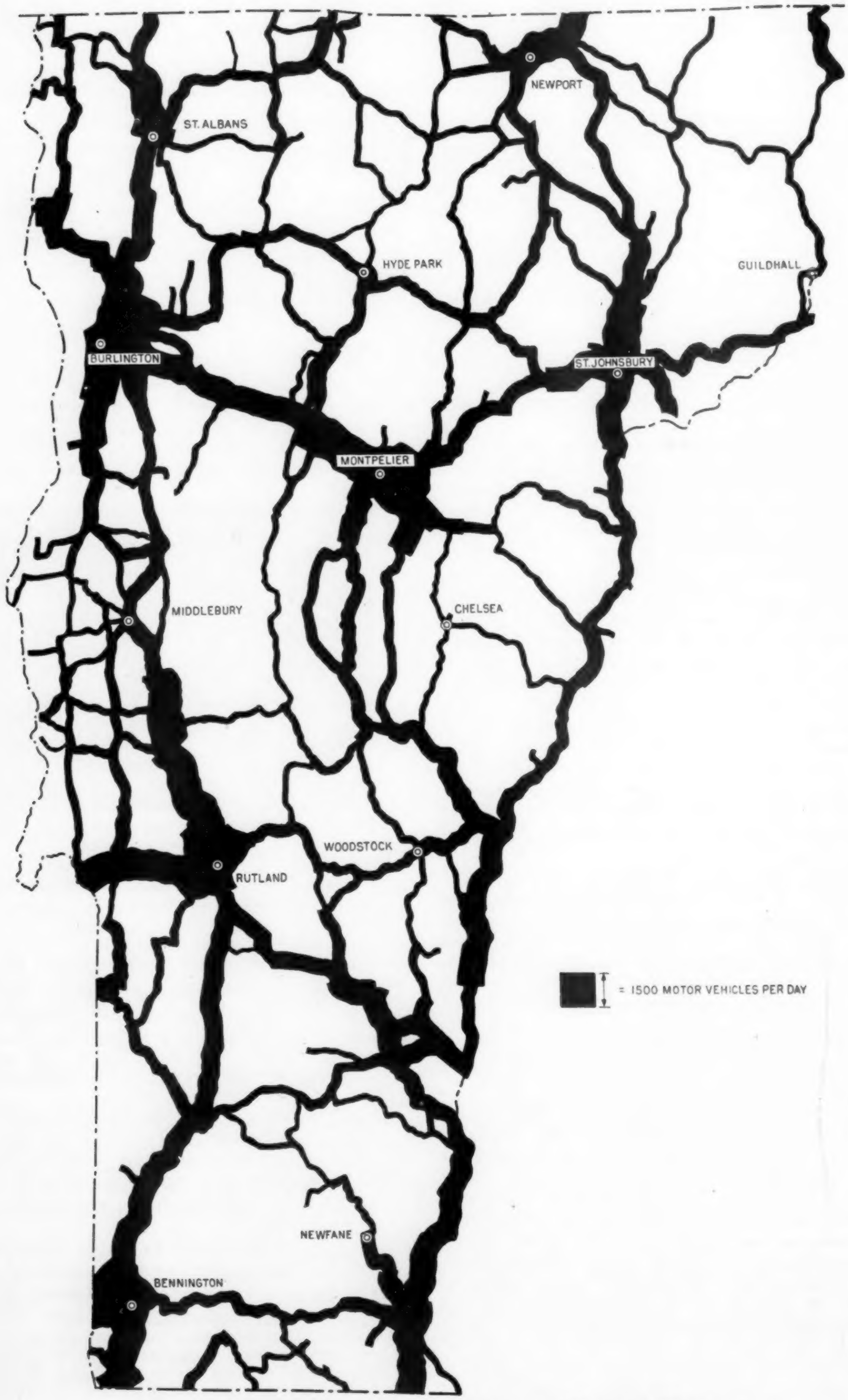
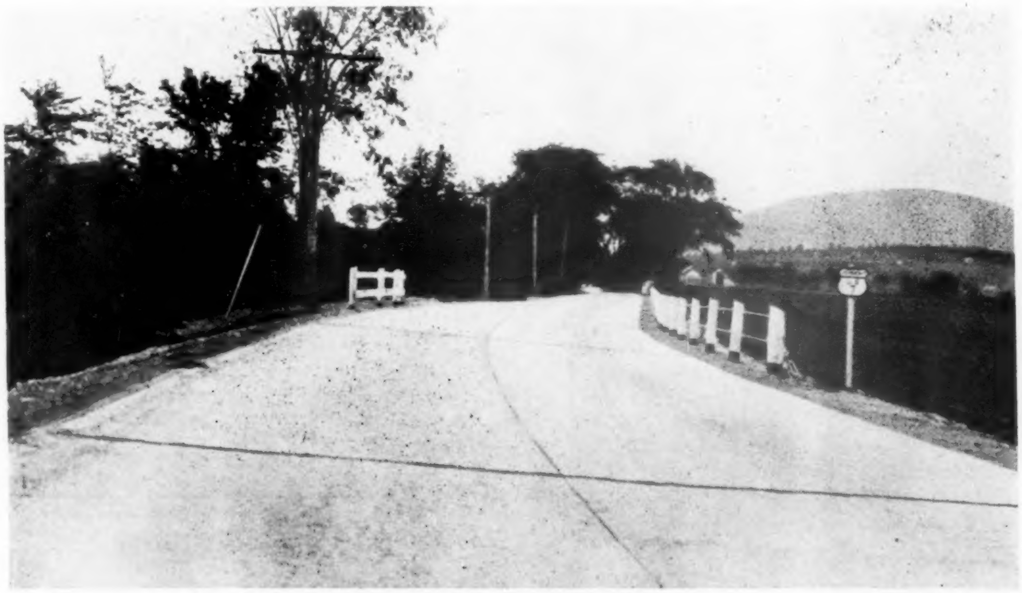


FIG. 1.—AVERAGE DAILY TRAFFIC DENSITY ON VERMONT HIGHWAYS

Upon the 14,582 miles of highway it is estimated that there was an average daily motor-vehicle movement during the period of the survey of 1,516,000 vehicle-miles.[3] The average daily density of traffic is shown in Figure 1.

The State roads, comprising 30.6 per cent of the total highway mileage, carried 87.2 per cent of this total traffic; and the town roads, embracing 69.4 per cent of the total mileage, carried only 12.8 per cent of the total traffic. The traffic on the State-aid roads averages over 15 times that on the town roads; on the Federal-aid system the traffic is more than double that on the numbered State-aid routes, and more than five times that on the unnumbered State-aid roads; and the traffic on the numbered State-aid routes is more than double that on the unnumbered State-aid roads.



A SECTION OF CONCRETE PAVEMENT CONSTRUCTED WITH FEDERAL AID ON ROUTE U. S. 7 NEAR POWNAL

Table 1 shows the mileage of Federal-aid and numbered State-aid routes by traffic classes in 1926.

The variation on individual sections of these routes is even greater. On the Federal-aid system, traffic varies from 2,673 vehicles daily on the section of heaviest traffic to approximately 100 vehicles on the least important sections. On the numbered State-aid routes, other than Federal-aid, and on the unnumbered State-aid routes, traffic of over 1,000 vehicles daily was observed only on very short sections immediately adjacent to the larger centers of population. The minimum traffic observed on the numbered routes was 33 vehicles; on the unnumbered roads several sections were observed which carried less than 10 vehicles per day. Of the town roads a considerable number of roads observed carry less than 5 vehicles per day, and very few were observed to carry over 100 vehicles per day. The comparatively small mileage of town roads carrying over 100 vehicles per day is found in the immediate vicinity of villages. There is a considerable mileage of town roads which, although officially public roads, are unopened and carry no traffic.

In the complete report the State is divided into six traffic sections which are somewhat comparable with the distribution of population and industry, and the traffic is analyzed on the various classes of highways in each of these sections.

TABLE 1.—*Mileage of Federal-aid and numbered State-aid routes, by traffic classes—1926*

Traffic class (vehicles per day)	Federal-aid routes		Numbered State-aid routes	
	Miles	*Per cent*	*Miles*	*Per cent*
Over 1,500	37	3.6		
1,200 to 1,499	64	6.1		
800 to 1,199	207	19.8	10	1.1
400 to 799	513	49.2	190	20.5
Less than 400	222	21.3	725	78.4
Total	1,043	100.0	925	100.0

[3] In this report certain terms, frequently used, have invariably the same meaning. These terms and their definitions are as follows:

Vehicles refers only to motor vehicles (passenger cars and trucks), exclusive of horse-drawn conveyances.

Traffic is defined as the movement to and fro of vehicles over a highway.

Density of traffic is defined as the number of motor vehicles passing any given point on a highway in a unit of time. For example, on route U. S. 2 between Montpelier and Barre the average daily density of traffic was 2,576 vehicles, which means that during an average 24-hour period 2,576 vehicles passed any given point on this 2 miles of highway. Unless a different unit of time is specifically stated, density of traffic refers to the number of vehicles passing any given point on the highway during a day of 24 hours. The accuracy of the determination of density of traffic is influenced by the distance between the survey stations. Exactness of method would require a density record for each point on the highway system where traffic varies. The cost involved in proportion to the relatively small gain in accuracy does not justify location of traffic observation points at close intervals. The density cumputed for each station on the Vermont highway system is applied to the short sections of highway reasonably adjacent to each station on which there is but little variation in traffic. In discussions of the utilization of the highway system, where it is desired to discriminate between the use of the highway by vehicles and the volume of traffic, the term *vehicle-miles per mile* is used in the former connection. Numerically, *vehicle-miles per mile* are equivalent to density of traffic.

Daily refers to a day of 24 hours.

Average daily refers to an average day during the period of the survey (July 16 to October 15, 1926).

Vehicle-mile is defined as the movement of a motor vehicle 1 mile.

Average daily vehicle-miles on the highway system are calculated by multiplying the average daily density of traffic on each section of highway by the length of the section in miles and adding the products.

Ton-mile is defined as the movement of a ton 1 mile.

Net tonnage refers to the net weight of the motor truck cargo.

Gross tonnage or *gross load* refers to the weight of the loaded motor truck, cargo and vehicle.

Foreign traffic or vehicles refers to vehicles having other than Vermont license tags. Foreign vehicle-miles are calculated by applying the percentage of foreign vehicles at each station to the total vehicle-miles on the sections of highway adjacent to each station and adding to obtain the total foreign vehicle-miles. Similar procedure is used in calculation of farm and city, business and nonbusiness, touring traffic, and trucking for hire.

FOREIGN TRAFFIC INCREASES COST OF HIGHWAY SERVICE

Foreign traffic, i. e., traffic of vehicles registered in other States, forms an important part of the total traffic on Vermont highways. The State is traversed by the main routes of tourist traffic between southern New England and Canada and between New York and the White Mountains and Maine coast resorts, and is in itself an important recreational area.

During the period of the survey, motor vehicles of foreign registration made up 35.6 per cent of the total traffic on the Federal-aid and numbered State-aid highways. Of the total passenger-car traffic, 36.6 per cent was of foreign registration, and the corresponding percentage for truck traffic was 9.6 per cent.

ROUTE U. S. 5 NEAR HARTLAND. THE ROAD IS SURFACED WITH GRAVEL. NOTE THE STANDARD CAUTION SIGN

Foreign-truck traffic is small in volume, and largely limited to the areas adjacent to the State boundaries. In capacity and loading the foreign-truck traffic is similar to Vermont truck traffic.

Of the 1,043 miles of Federal-aid highways, 114 miles carried foreign passenger-car traffic in excess of 500 vehicles daily, 513 miles carried between 200 and 500 foreign vehicles, and 416 miles less than 200 foreign vehicles.

Route U. S. 7, from the Massachusetts line near Pownal to the Canadian border near Highgate Springs, carried the greatest volume of foreign passenger-car traffic, such traffic being 43.3 per cent of the total passenger-car traffic on the route. The large volume of foreign traffic on Vermont highways adds considerably to the cost of providing highway service on the main routes of travel. This volume of foreign traffic, in addition to local Vermont traffic, results in increased maintenance costs on present improvements, which are loaded beyond their economic capacity, and makes necessary earlier improvement or reconstruction of these routes by the construction of surfaces superior to gravel. The present contribution of foreign traffic to Vermont highway revenue is limited very largely to that derived from the taxation of gasoline sold to operators of foreign cars and it is doubtful if this revenue is at all commensurate with the increased cost of providing highway service caused by foreign traffic.

TRUCKING IMPORTANT ONLY ON SHORT SECTIONS OF THROUGH ROUTES

Except on a comparatively small part of the highway mileage, motor-truck traffic on the highways of the State is a minor part of total motor-vehicle traffic. The construction of surfaces to carry passenger cars will in the majority of cases be adequate for such motor-truck traffic as there is. There are, however, major-traffic routes, particularly those near the larger cities and villages, on which the density of truck traffic is sufficiently great to require special consideration in highway planning.

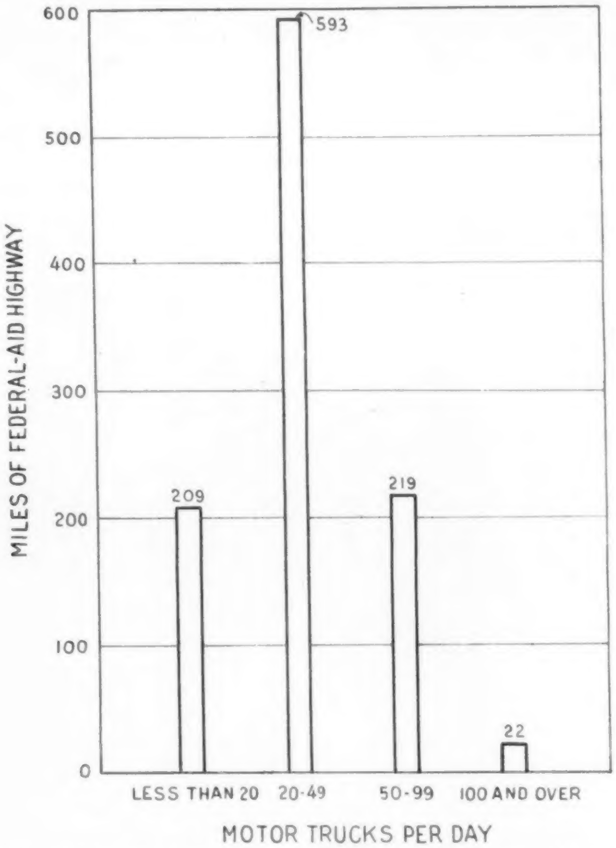


FIG. 2.—CLASSIFICATION OF FEDERAL-AID ROAD MILEAGE ACCORDING TO THE NUMBER OF MOTOR TRUCKS CARRIED

There is a large mileage of road that carries less than 50 trucks a day, even on the Federal-aid system, as shown by Figure 2. Of the 1,043 miles of the latter system, only 241 carry 50 or more trucks a day; and of the 925 miles of numbered State-aid routes, only 48 miles carry truck traffic of that density.

Approximately 35 per cent of the mileage of the Federal-aid and numbered State-aid highways carried less than 20 trucks per day, and 85.3 per cent less than 50 trucks. On 13.6 per cent of the mileage there was a density of from 50 to 99 trucks, and on 1.1 per cent 100 or more trucks per day.

No one route stands out as a main trucking route. There are short sections on practically every important highway route which carry a considerable number of trucks. These sections are distributed throughout the State. The longest is on Route U. S. 2 from Burlington to East Barre, a distance of 37.9 miles, on which motor-truck traffic varied from 60 to 161 trucks at various points.

Practically all of the important trucking routes in the State are included in the Federal-aid system; and of the Federal-aid mileage carrying 50 or more trucks per day, approximately two-thirds is on the United States routes.

CAPACITY AND LOADING OF TRUCKS ANALYZED

The provision of highway facilities for motor-truck traffic in Vermont involves varied problems according to the capacity and weight of trucks as well as the density of the traffic. On roads where few or no trucks of 2 tons or larger capacity were found, highway planning need make no other provision than that required for passenger-car traffic. Trucks of less than 2 tons capacity, 97 per cent of which are equipped with pneumatic tires on their rear wheels,[4] have much the same effect upon highway surfaces as passenger cars.

Where trucks of 2 tons or greater capacity occur in appreciable numbers they must be given consideration in highway planning. These trucks carry considerably heavier loads than passenger cars and approximately 53 per cent of them are equipped with other than pneumatic tires on the rear axle.

Figure 3 shows the distribution by capacity groups of loaded motor trucks observed on the highways of the State.

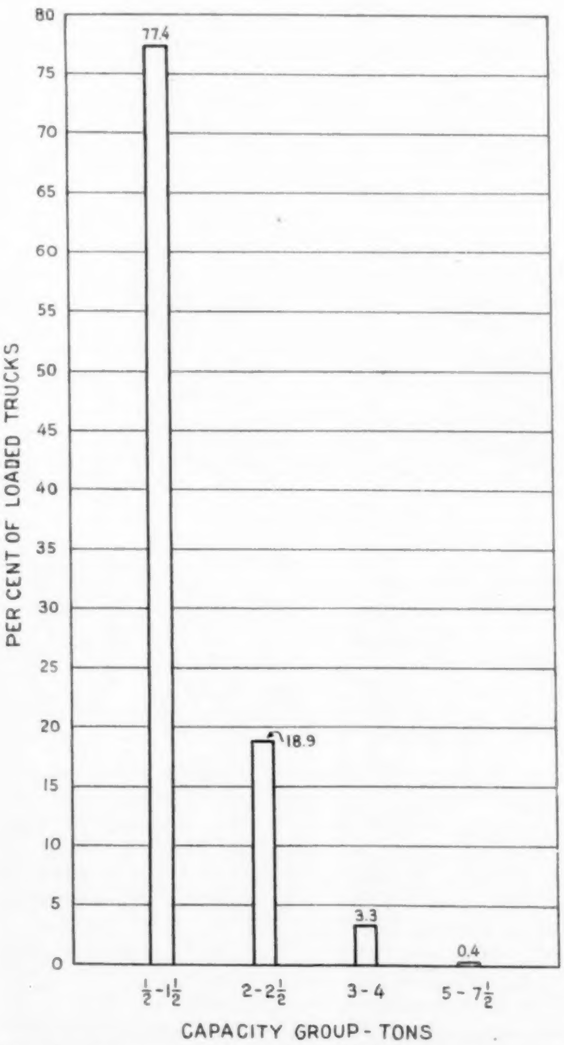


Fig. 3.—Distribution of Loaded Motor Trucks by Capacity Classes

[4] The rear axle of a truck delivers a greater impact to the road surface because it carries, on an average in Vermont, 69 per cent of the total gross load.

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Motor trucks of 2 to 2½ tons capacity were approximately one-fifth of the observed trucks, those of less than 2 tons capacity 77.4 per cent, those of 3 to 4 tons capacity comprised only 3.3 per cent, while those of 5 tons or greater capacity, being only 0.4 per cent of the total number of trucks observed, were a negligible part of the total truck traffic.

An Attractive Vista on the Connecticut River Road. The Road Has an Oiled Gravel Surface

As shown in Table 2, loaded trucks of less than 2 tons capacity carry an average cargo of 1,800 pounds and have an average gross load of 5,140 pounds.

Table 2.—*Average weight per loaded truck by capacity classes*

Capacity class	Loaded trucks	Average net weight of cargo	Average gross weight
Tons:	*Number*	*Pounds*	*Pounds*
½ to 1½	2,523	1,800	5,140
2 to 2½	524	4,920	12,410
3 to 4	112	5,490	15,100
5 to 7½	4	8,200	20,300

That motor-truck traffic in Vermont is predominantly a movement of small trucks carrying light loads is further indicated by the fact that 72.8 per cent of the loaded trucks weigh less than 8,000 pounds gross and 87.4 per cent less than 12,000 pounds gross. Only 3.9 per cent weigh 16,000 or more pounds, as shown in Table 3.

TABLE 3.—*Loaded trucks classified by gross weight*

Gross weight	Loaded trucks		Average net weight of cargo	Average gross weight
Thousand pounds:	*Number*	*Per cent*	*Pounds*	*Pounds*
Less than 4	869	27.5	630	3,060
4 to 8	1,431	45.3	2,000	5,640
8 to 12	463	14.6	3,600	9,580
12 to 16	276	8.7	5,680	13,800
16 and over	124	3.9	9,030	18,280
Total	3,163	100.0	2,450	6,710

Trucks of over 16,000 pounds gross weight carry an average cargo of 9,030 pounds and have an average gross weight of 18,280 pounds.

THE RIVER ROAD BETWEEN FARLEY AND BRADFORD—A GRAVEL ROAD CONSTRUCTED WITH FEDERAL AID

Extensive use of trucks of 2 tons capacity or larger is limited to a relatively small mileage of the highways of the State. On Federal-aid highways, the principally traveled routes of the State, less than 10 trucks of 2 tons or larger capacity are found on 68.4 per cent of the mileage as shown in Table 4.

TABLE 4.—*Mileage of Federal-aid and other numbered State-aid highways by density of traffic of 2-ton or larger trucks*

Two-ton and larger trucks per day	Federal-aid highways		Other numbered State-aid highways	
	Miles	*Per cent*	*Miles*	*Per cent*
0 to 9	713	68.4	839	90.7
10 to 19	284	27.2	59	6.4
20 to 29	36	3.4	21	2.3
30 and over	10	1.0	6	.6
Total	1,043	100.0	925	100.0

MOTOR-BUS AND MOTOR-TRUCK LINES ARE OF INCREASING IMPORTANCE

Motor-bus traffic, although small in total volume, is important on certain of the Federal-aid and numbered State-aid routes, and on a few of the unnumbered State-aid roads.

In 1926 there were 52 companies or individuals licensed by the public service commission, engaged in intrastate and interstate bus transportation, operating on regular schedules over approximately 671 miles of Federal-aid roads, 168 miles of numbered State-aid and 62 miles of unnumbered State-aid routes.

On portions of several of the main routes two or more bus lines operate, some being through lines and others serving the local communities. Burlington, Rutland, Montpelier, and White River Junction are the principal termini of motor-bus transportation lines.

The busses observed varied in capacity from 5 to 38 passengers each; approximately one-third had a capacity of less than 10, and one-half a capacity of 20 or more passengers.

Busses of small passenger capacity are similar to the ordinary passenger automobile and require no special consideration, but the large-capacity bus traveling at high speed may, when present in large numbers, require special consideration both as to width of surface and design of pavement.

In 1926 there were 16 licensed trucking concerns operating over fixed routes and on regular schedules. These routes covered approximately 346 miles of Federal-aid routes, 74 miles of numbered State-aid routes, and 17 miles of unnumbered State-aid roads.

The capacities of trucks engaged in this form of common-carrier transportation varied from 1 to 2½ tons.

While the tonnage hauled by companies operating for hire is small compared to the tonnage of the total truck traffic, it is of growing importance in those sections which have inadequate railroad transportation.

SURVEY SHOWS EXTENT OF HIGHWAY USE

During the period of the survey, motor-vehicle traffic on the highways of the State, of which there are 14,582 miles, was approximately 139,472,000 vehicle-miles, an average of 1,516,000 vehicle-miles per day. The distribution of this traffic by classes of highway—Federal-aid, other numbered State-aid routes, unnumbered State-aid routes, and town roads—is shown in Table 5.

TABLE 5—*Motor vehicle utilization and mileage of Vermont highways by systems*

Highway system	Highway mileage		Average daily vehicle-mileage		Average daily density of traffic
	Miles	*Per cent*	*Vehicle-miles*	*Per cent*	
Federal-aid system	1,043	7.2	732,000	48.3	702
Numbered State-aid routes [1]	925	6.3	271,000	17.9	293
Unnumbered State-aid routes	2,494	17.1	318,000	21.0	128
Town roads	10,120	69.4	195,000	12.8	19
Total	14,582	100.0	1,516,000	100.0	

[1] Numbered State-aid routes other than Federal-aid routes. The numbered State-aid routes in 1926 included the Federal-aid system of 1,043 miles, and other numbered routes, 925 miles, a total of 1,968 miles.

The Federal-aid highway system, 7 per cent of the certified highway mileage and 7.2 per cent of the mileage of traveled public roads, carried approximately one-half of the total traffic on all roads of the State. The present numbered routes, 13.5 per cent of the highway mileage, which includes the Federal-aid system, carried two-thirds of the total traffic. Town roads, 69.4 per cent of the total highway mileage, carried only 12.8 per cent of the traffic.

The routes selected for uniform numbering by the American Association of State Highway Officials; including U. S. 2, U. S. 4, U. S. 5, and U. S. 7 are the most important through traffic routes in the State. These routes, aggregating 525 miles in length, approximately 50 per cent of the Federal-aid system, carry approximately 60 per cent of the traffic on the system.

The primary Federal-aid routes, 446 miles, three-sevenths of the Federal-aid system, carry 53 per cent of the traffic on the system.

COMPOSITION OF TRAFFIC DISCUSSED

The comparative use of the highways of the State by vehicles of Vermont and foreign registration, by city and farm-owned vehicles, and by various other types of vehicles can be expressed accurately in vehicle-miles.[5]

The total passenger-car use of the Federal-aid and numbered State-aid roads on an average day, during the transportation survey, was 940,600 passenger-car-miles. The distribution of this traffic according to registration, ownership, type of trip, and type of usage of cars is shown in Table 6.

TABLE 6.—*Composition of passenger car traffic on the Federal-aid and numbered State-aid roads*

Type of passenger car traffic	Daily passenger-car-miles	Percentage of daily passenger-car-miles
State of registration:		
Vermont	596,300	63.4
Foreign	344,300	36.6
Place of ownership:		
City	845,600	89.9
Farm	95,000	10.1
Type of trip:		
Touring	134,500	14.3
Nontouring	806,100	85.7
Type of usage:		
Business	317,000	33.7
Pleasure	623,600	66.3
All types	940,600	100.0

STANDARD U. S. ROUTE MARKER ON U. S. ROUTE NO. 5, NEAR HARTLAND

Foreign traffic amounts to 344,300 passenger-car-miles per day, or 36.6 per cent of the total passenger-car mileage.

The traffic of farm-owned passenger cars comprises 10.1 per cent and of city-owned passenger cars, 89.9 per cent of the total passenger-car traffic on the Federal-aid and numbered State-aid routes.

The volume of farm-owned passenger-car traffic varies with the agricultural development of the area served by the routes but is more nearly uniform on all routes than is the case with city-owned traffic. On heavy-traffic routes farm-owned traffic forms a very small part of the total. On light-traffic routes off the main routes of travel and not adjacent to centers of population, farm-owned traffic forms a much larger part of total traffic.

The importance of long-distance touring traffic on Vermont highways is indicated by the fact that 14.3 per cent of the total passenger-car traffic, measured in vehicle-miles, is made up of touring trips. This traffic is largely of foreign registration and limited to the main through routes and routes leading to points of historic or scenic interest.

Approximately two-thirds of the passenger-car traffic, measured in vehicle-miles, on the Federal-aid and other numbered State-aid routes is made up of cars used for pleasure or recreational purposes. This traffic is limited largely to the main routes of travel, the scenic routes, and routes in the summer-resort areas.

The distribution by length of trip, as shown in Table 7, is based on the entire trip from point of origin to point of destination, which—particularly for long-distance traffic—includes a considerable mileage on highways of adjacent States. The average total trip mileage and trip mileage on highways of Vermont for each type of passenger car traffic are shown in Table 8.

[5] The various types of traffic are defined as follows:
State of registration: *Vermont* includes all motor vehicles registered in Vermont; foreign includes all motor vehicles not registered in Vermont.
Place of ownership: *Farm* includes all motor vehicles owned by persons residing on farms; city includes all motor vehicles owned by persons residing in cities, villages, or urban areas.
Type of usage: *Business* indicates that the car on the trip recorded was being used for business purposes; *pleasure* indicates that the car on the trip recorded was being used for pleasure or recreational purposes.
Type of trip: *Touring* includes all trips of more than one day's duration taken primarily for recreation; *nontouring* includes all other trips.
Type of trucking: *For hire* includes all trucks engaged in hauling commodities either on a contract or tariff basis.

TABLE 7.—*Distribution of passenger-car traffic by length of trip* [1]

Length of trip	Type of passenger-car traffic								
	Total	Vermont	Foreign	City	Farm	Touring	Nontouring	Business	Pleasure
Miles	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Less than 10	29.8	42.0	10.8	28.1	75.6	0.0	36.3	43.0	23.1
10 to 19	16.1	21.9	6.9	16.1	15.0	0.0	19.6	21.6	13.3
20 to 29	6.9	8.7	4.1	7.0	3.7	0.0	8.4	7.9	6.4
30 to 39	5.0	6.1	3.1	5.1	2.7	0.0	6.1	5.0	5.0
40 to 49	3.8	4.5	2.7	3.9	1.0	0.0	4.6	3.8	3.8
50 to 59	2.4	2.6	2.0	2.5	0.0	0.4	2.8	1.7	2.7
60 to 69	1.9	2.1	1.6	1.9	0.3	0.5	2.2	2.1	1.8
70 to 79	1.8	1.8	1.8	1.8	0.7	1.1	1.9	1.6	1.8
80 to 89	1.5	1.3	1.8	1.5	0.0	1.0	1.6	1.3	1.6
90 to 99	1.4	1.2	1.7	1.5	0.0	0.8	1.5	0.9	1.7
100 to 149	5.3	3.6	8.1	5.5	1.0	4.2	5.6	4.6	5.7
150 to 199	4.0	1.4	8.1	4.1	0.0	6.4	3.5	2.4	4.8
200 to 299	8.4	1.8	18.8	8.8	0.0	27.6	4.3	2.8	11.3
300 and over	11.7	1.0	28.5	12.2	0.0	58.0	1.6	1.3	17.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Based upon a total of 8,262 cars.

TABLE 8.—*Average mileage per trip and average passengers per car for various types of passenger-car traffic*

Type of traffic	Average mileage per trip [1]		Average number of passengers per car
	Total	On Vermont highways	
State of registration:			
Vermont	31	24	2.7
Foreign	199	75	3.0
Place of ownership:			
City	102	46	2.8
Farm	12	11	2.4
Type of trip:			
Touring	348	118	3.3
Nontouring	47	30	2.7
Type of usage:			
Business	38	25	1.9
Pleasure	123	52	3.2

[1] Averages shown are the arithmetic mean of the trip-mileage of cars observed. This average is influenced greatly by exceptionally long trips, but provides a reliable basis of comparing the various types of traffic.

Average daily motor-truck use of the Federal-aid and other State-aid highways during the period of the survey was 62,400 vehicle-miles. The distribution of this traffic by place of registration, ownership, and type of trucking is shown in Table 9.

TABLE 9.—*Composition of motor-truck traffic on the Federal-aid and numbered State-aid roads*

Type of truck traffic	Average daily truck-miles	Per cent of total daily truck-miles
State of registration:		
Vermont	56,400	90.4
Foreign	6,000	9.6
Type of trucking:		
For hire	13,900	22.2
Other than for hire	48,500	77.8
Place of ownership:		
City	50,600	81.1
Farm	11,800	18.9
Total	62,400	100.0

The proportionate use of highways in the State by trucks of foreign registration is considerably less than the use by foreign passenger cars. As shown in Table 9 only 9.6 per cent of the total motor-truck miles is produced by foreign trucks.

Foreign trucks operate primarily upon the principally traveled routes near the State boundaries. Used household furniture, fresh fruits, groceries, gasoline, and bakery goods are the principal commodities hauled by them.

Little difference was found in the average net cargo hauled by Vermont and foreign trucks, that of the former being 2,460 pounds and of the latter 2,360 pounds.

The use of the Federal-aid and numbered State-aid roads by trucks for hire totals 13,900 truck-miles per day, or 22.2 per cent of the total truck use of these highways. These trucks are engaged principally in the hauling of clay, gravel, sand, stone, milk, lumber, used household furniture, and general freight. Approximately 70 per cent of the trucks operating for hire are engaged in the transportation of these commodities. The average net cargo of trucks operated for hire is 3,300 pounds as compared with 2,240 pounds for other trucks.

City-owned trucks comprise 81.1 per cent of the motor-truck use of the same systems as shown in Table 9. The loads carried by city-owned trucks are considerably greater than those hauled by farm-owned trucks. The average net cargo hauled by city trucks is 2,710 pounds as compared with 1,270 pounds for farm-owned trucks. This small cargo hauled by farm-owned trucks and a correspondingly low gross weight indicate that the use of the highways of the State by farm-owned trucks is mainly by small-capacity trucks, hauling light loads.

That motor-truck traffic is primarily a local and short-haul movement is shown by Table 10. Of the loaded trucks observed on the principal highways of the State, 45.2 per cent were traveling less than 10 miles per trip and 78.4 per cent less than 30 miles. Of the net tonnage of commodities transported 42.7 per cent was being hauled less than 10 miles and 78 per cent less than 30 miles. Only 7.8 per cent of the net tonnage hauled by loaded trucks was transported 60 miles or more.

TABLE 10.—*Distribution of motor-truck traffic by length of trip* [1]

Length of trip	Motor trucks	Net cargo tonnage
Miles:	*Per cent*	*Per cent*
Less than 10	45.2	42.7
10 to 19	22.9	25.8
20 to 29	10.3	9.5
30 to 39	6.3	6.4
40 to 49	5.0	5.0
50 to 59	2.8	2.8
60 to 69	1.3	1.3
70 to 79	1.0	1.1
80 to 89	.8	.7
90 to 99	.6	.6
100 and over	3.8	4.1
Total	100.0	100.0

[1] Based upon 3,163 loaded trucks.

The distribution by lengths of trip, as shown in Table 10, is based on the total trip from point of origin to point of destination, which—particularly for the longer trips—includes the mileage traveled on highways of adjacent States. The average total trip mileage, the trip mileage on the highways of Vermont, the average net cargo weight and the average gross weight per truck for each type of truck traffic are shown in Table 11.

TABLE 11.—*Average mileage per trip and average weight per truck for various types of motor-truck traffic*

Type of truck traffic	Average mileage per trip [1]		Average weight	
	Total	On Vermont highways	Net cargo	Gross
State of registration:			*Pounds*	*Pounds*
Vermont	19	16	2,460	6,660
Foreign	59	30	2,360	7,260
Type of trucking:				
For hire	24	18	3,300	8,040
Other than for hire	23	18	2,240	6,380
Place of ownership:				
City	26	20	2,710	7,200
Farm	12	11	1,270	4,440

[1] Averages shown are the arithmetic mean of trip mileage of trucks observed. This average is influenced by the relatively small number of long trips but provides a reliable basis of comparing the various types of traffic.

FUTURE TRAFFIC FORECAST

Since no adequate historical series of traffic records are available in Vermont it is impossible to make a forecast based directly upon past trends. In States where historical series of traffic records are available highway traffic and motor-vehicle registration have been found to increase at equal rates. A comparison of highway traffic and motor-vehicle registration in Maine, Maryland, Massachusetts, Michigan, and Wisconsin is shown in Figure 4.

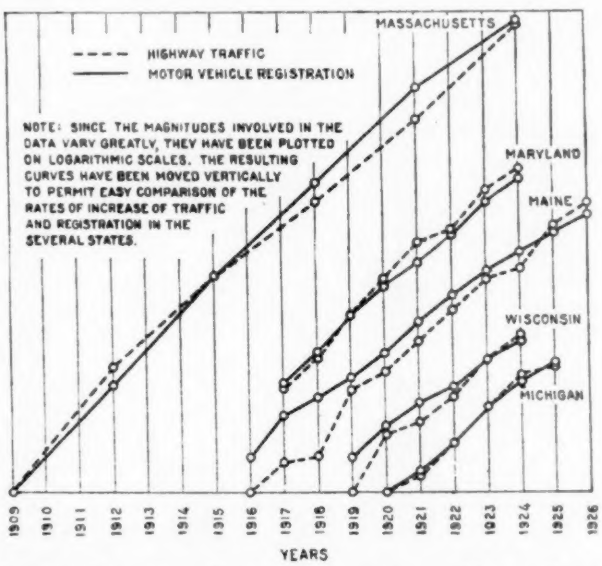

FIG. 4.—TRENDS OF HIGHWAY TRAFFIC AND MOTOR VEHICLE REGISTRATION IN MASSACHUSETTS, MARYLAND, MAINE, WISCONSIN, AND MICHIGAN

Vermont varies from these States with respect to traffic growth principally in the volume of foreign traffic on the more important highways and in the rate of population increase. The proportion of foreign traffic on Vermont highways was recorded at 33 points during a traffic count conducted by the State highway department in August, 1924. At 32 of these points, which were similar in location to stations of the 1926 survey, it was found that 38.1 per cent of the cars were of foreign registration. At the 32 similarly located stations during the 1926 survey it was found that 38.6 per cent of the traffic was foreign. In New Hampshire, which also has a large volume of foreign traffic, traffic counts obtained in 1918, 1922, and 1926 indicate that foreign traffic at corresponding points was 41 per cent of the total in 1918; 40 per cent in 1922; and 48 per cent in 1926.

These data indicate that foreign traffic in these States is increasing slightly more rapidly than local traffic and that a forecast of total traffic on Vermont highways based on motor-vehicle registration in the State would be conservative, but for a short period of years would represent total traffic with reasonable accuracy.

A BITUMINOUS MACADAM ROAD NEAR ADDISON

Motor-vehicle registration can be predicted on the basis of exact records available since 1913. The increase in motor-vehicle registration is a function of two variables (1) increase in population and (2) the increase in ownership and use of motor vehicles in proportion to population, measured by the number of persons per motor vehicle.

Population, motor-vehicle registration, and persons per car from 1913 to 1926 and extended to 1936 are shown in Table 12.

The persons per car for each year from 1913 to 1925 and the extension of the trend to 1936 are shown in Figure 5.

The trend of motor-vehicle registration in Vermont from 1913 to 1926, inclusive, indicates an increase in registration of 39.8 per cent between 1926 and 1931, and of 24.5 per cent between 1931 and 1936, or an increase of 74 per cent for the 10-year period from 1926 to 1936.[6] Assuming a uniform rate of increase in traffic and motor-vehicle registration, traffic may be expected to increase in the same ratio as the registration.

This rate of increase in highway traffic will apply for the State as a whole. Traffic originating in the areas of the State which are rapidly increasing or de-

[6] Based on actual registration in 1926, which is the measure of traffic for this year and estimated registration in 1931 and 1936.

TABLE 12.—*Comparison of population and the number of motor vehicles in the State of Vermont*

Year	Population [1] (hundreds)	Registration of motor vehicles (hundreds)		Persons per car	
		Actual	Estimated	Actual	Estimated
1913	3,548	59	62	60.0	57.6
1914	3,544	85	85	41.8	41.6
1915	3,541	115	114	30.8	31.1
1916	3,537	157	149	22.6	23.8
1917	3,533	216	188	16.3	18.8
1918	3,530	226	233	15.6	15.1
1919	3,526	268	284	13.2	12.4
1920	3,524	316	339	11.1	10.4
1921	3,524	373	397	9.46	8.87
1922	3,524	439	459	8.03	7.68
1923	3,524	528	523	6.68	6.74
1924	3,524	612	589	5.76	5.99
1925	3,524	696	655	5.07	5.38
1926	3,524	741	722	4.76	4.88
1927	3,524		788		4.47
1928	3,524		853		4.13
1929	3,524		916		3.85
1930	3,524		977		3.61
1931	3,524		1,036		3.40
1936	3,524		1,290		2.73

[1] Population as of July 1, each year. For the years 1913 to 1923, inclusive, the populations given are Bureau of Census estimates. Those for the years 1924 to 1936, inclusive, are extensions by the method used by the Bureau of the Census.

creasing in population will increase more or less rapidly than the average. Such areas, however, are small and, considering the volume of traffic on the principal highways which originates outside of the immediate local areas, the application of a uniform rate of traffic increase to the entire State is justified.[7]

The expected traffic in 1931 was obtained by applying the rates of motor-vehicle registration and traffic increase to the 1926 traffic at each survey station. The resulting forecast of traffic at each station is shown in the full report.

ROUTES CLASSIFIED ACCORDING TO PRESENT AND FUTURE TRAFFIC

To provide a basis for the establishment of a balanced program of highway improvement to meet traffic needs in Vermont a traffic classification of Vermont highways has been established on the basis of the principal traffic data, which are (1) total present motor-vehicle traffic and estimated traffic in 1931 and 1936, (2) total truck traffic, and (3) traffic of large-capacity trucks. The highways are classified in three groups, designated as major, medium, and minor traffic routes or sections of routes, according to their average daily present and estimated future traffic.

These classes and the traffic limits of each class are summarized in Table 13:

TABLE 13.—*Traffic classification of Vermont highways and traffic limits for each class for 1926 and estimated for 1931 and 1936*

Traffic classification [1]	Average daily motor vehicles		
	1926	1931	1936
Major 1	1,500 or over	1,500 or over	1,500 or over.
Major 2	800 to 1,500	1,500 or over	1,500 or over.
Medium 1	800 to 1,500	800 to 1,500	1,500 or over.
Medium 2	800 to 1,500	800 to 1,500	800 to 1,500.
Medium 3	Less than 800	800 to 1,500	800 to 1,500.
Minor 1	Less than 800	Less than 800	800 to 1,500.
Minor 2	Less than 800	Less than 800	Less than 800

[1] The traffic classifications for 1931 and 1936 are based on average traffic in 1926.

The above traffic limits are based primarily upon experience and present practices in Vermont. The upper limit of the minor group is higher than that commonly accepted in many States, but is in accordance with Vermont traffic conditions, particularly the very limited use of trucks of over 2½ tons capacity, and the resulting absence of heavy wheel loads, the fact that observed traffic represents traffic during the period of greatest traffic density, and the serviceable type of gravel available for construction of gravel roads in Vermont. The more important routes included in the minor classification, and classified as requiring gravel surfaces, should be surface treated.

All highways upon which the traffic was observed are classified, including the entire Federal-aid system, practically all of the other numbered State-aid routes and approximately one-tenth of the unnumbered

(Continued on p. 229)

[7] The validity of this assumption is substantiated by an analysis of registration increase by towns in New Hampshire for the years 1922 to 1925, inclusive. Notwithstanding variations in population density, population trends and present persons per car, the rate of decrease in persons per car in the different areas was very uniform.

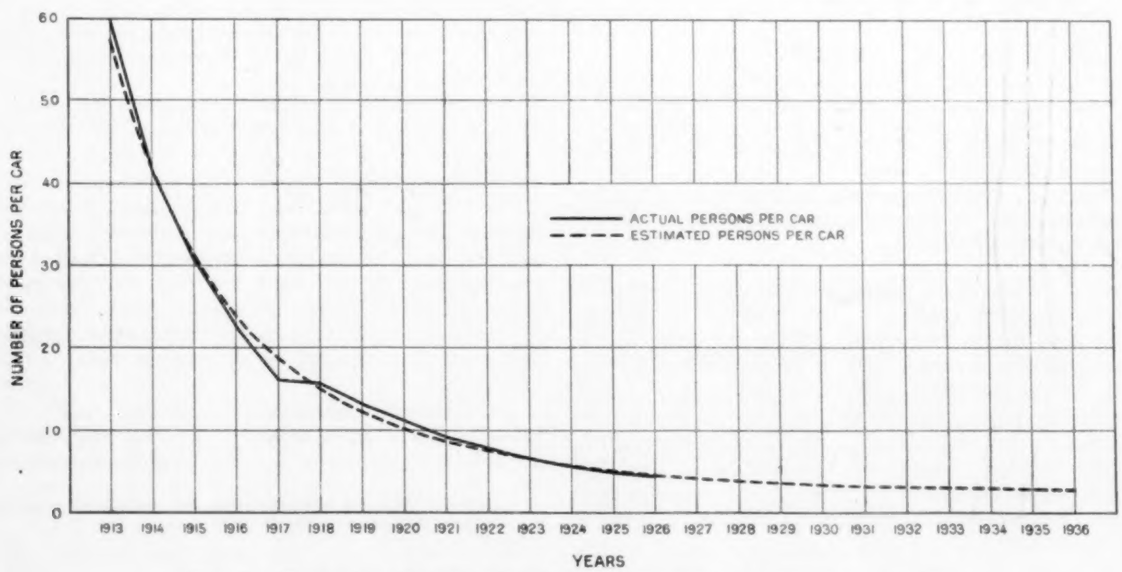

FIG. 5.—NUMBER OF PERSONS PER MOTOR VEHICLE IN VERMONT BY YEARS

RELATION BETWEEN SODIUM SULPHATE SOUNDNESS TEST AND ABSORPTION OF SEDIMENTARY ROCK

By the Division of Tests, United States Bureau of Public Roads, Reported by D. O. WOOLF, Jr., Materials Engineer

FOR a number of years past an accelerated sodium sulphate soundness test has been used to indicate the resistance of sedimentary rock to repeated frost action. This test was apparently first proposed by M. Brard, and is described in Annales de Chemie et de Physique (1828). It has recently been tentatively accepted by the American Association of State Highway Officials as a standard test.

The test consists of alternately immersing the test sample of rock in a saturated solution of sodium sulphate for 20 hours and drying it at 100° C. for four hours. This operation is repeated five times and then the sample is examined as to appearance and the rock classified as sound or unsound. Samples which crack, check, or disintegrate are considered as unsound and of questionable suitability for use in concrete which is exposed to frost action.

Several attempts have been made to correlate the accelerated sodium sulphate soundness test of rock with the results of other tests which are usually made

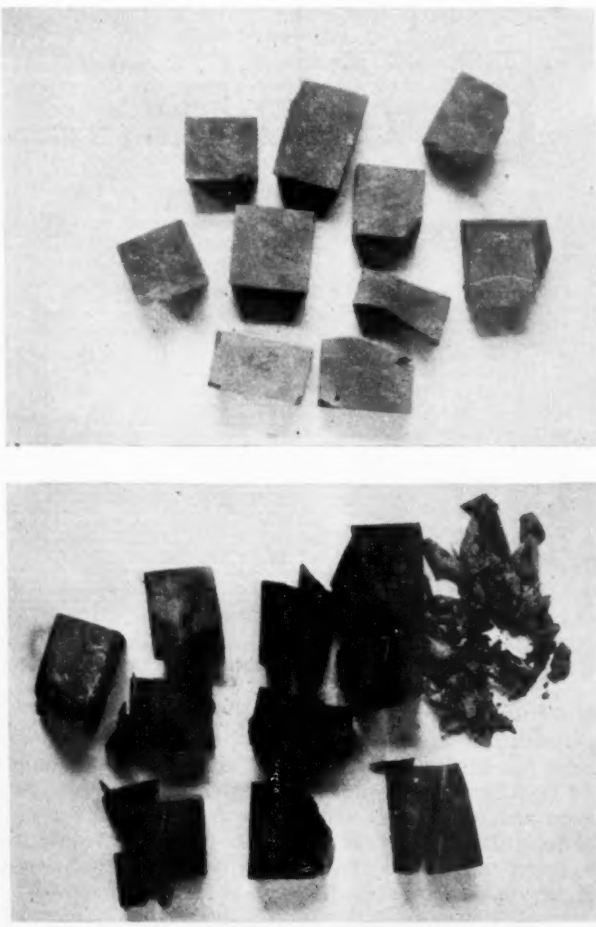

FIG. 1.—A LIMESTONE SAMPLE BEFORE AND AFTER THE SOUNDNESS TEST. THE RECTANGULAR APPEARANCE IS BECAUSE SAWED MATERIAL WAS SUBMITTED FOR TESTING AND IS NOT CHARACTERISTIC OF SAMPLES PREPARED FOR TESTING

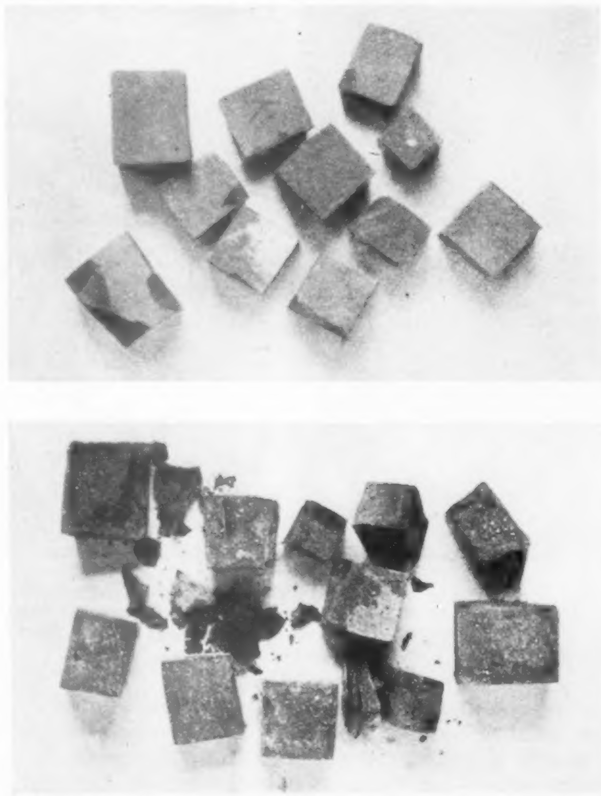

FIG. 2.—A LIMESTONE SAMPLE BEFORE AND AFTER TESTING

to determine the quality of the material. These comparisons have usually shown negative results, i. e., there is no apparent relationship between the results of the soundness test and any of the standard tests. Considering, however, that failure in the accelerated soundness test may be caused through crystal growth in the interior of a rock specimen, it is believed that there must be some relation between the soundness test and a test of the porosity of the material. This latter property is usually determined by an absorption test, the test result expressing the amount of absorbed water in terms of percentage of the dry weight of the solid rock.

For the last three years the Bureau of Public Roads has been making the accelerated soundness test on all rock samples of sedimentary origin as well as marble which have been submitted for test to determine their suitability for use in concrete, and the tests reported in this paper include the great majority made on such rock. One hundred and fifty of these rocks have also been tested for absorption. The results of these tests are shown in Table 1, and, although they do not establish a definite relation between percentage of absorption and unsoundness as determined by the sodium sulphate test, they do indicate that rocks having a certain percentage of absorption will in the greater number of cases prove to be unsound. It is believed

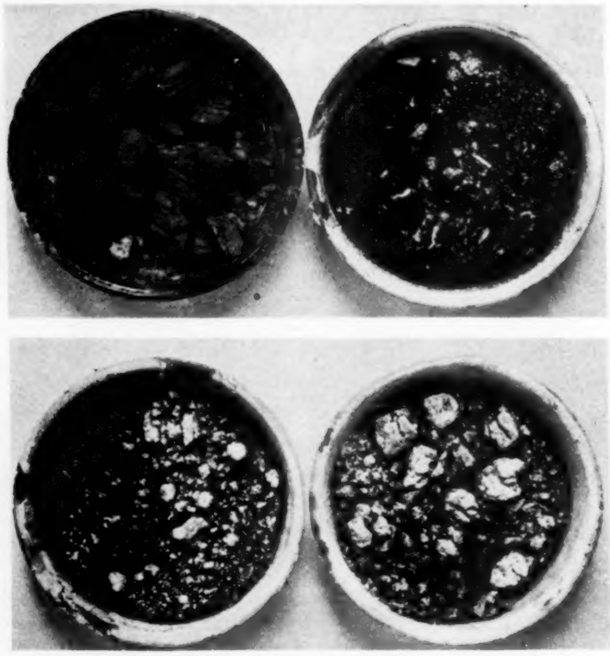

Fig. 3.—Three Samples Which Have Completely Disintegrated in the Soundness Test and One Showing Parallel Parting. All of These Samples Had More Than 4 Per Cent Absorption

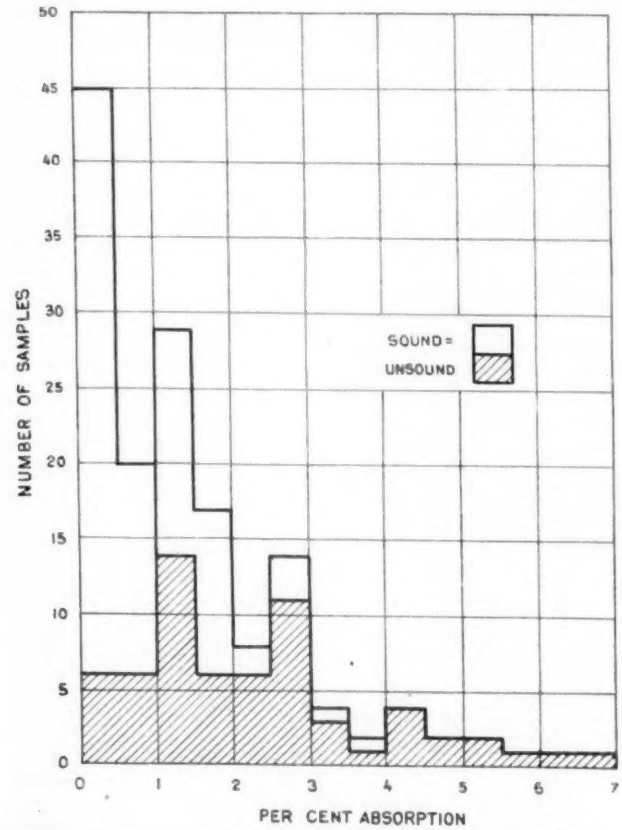

Fig. 4.—Proportion of Sound and Unsound Samples Grouped According to Percentage of Absorption

that the samples shown in Table 1 include all types and qualities of sedimentary rock which are used as coarse aggregate in concrete, and the range in test values, as will be noted, is quite extensive, the absorption ranging to above 6.5 per cent. Results of the standard Deval abrasion test are not shown but they varied from a minimum of 2.3 per cent to a maximum of 26.2 per cent. The geographical distribution of the samples is shown in Table 2.

Figures 1 to 3 show typical examples of failure in the accelerated soundness test. Figures 1 and 2 show samples of unsound rock before and after the test. Figure 3 shows three completely disintegrated samples and one in which parallel parting is excellently marked. These samples (fig. 3) had very high absorptions, all of them being greater than 4 per cent.

Figure 4 shows the proportion of sound and unsound samples grouped according to percentages of absorption. Each group covers a range of 0.5 per cent, the first group including all values up to 0.5 per cent, the second from 0.51 to 1, etc. Figure 5 shows the number of samples having percentages of absorption equal to or greater than 0, 1, 2, 3, etc., and the percentage of all such groups shown to be unsound by the soundness test.

It will be noticed that of all the samples tested, 43 per cent were unsound. Of all samples tested which had an absorption of 2 per cent or more, 82 per cent were unsound. All samples with an absorption of 4 per cent or more were unsound. On the basis of the group of samples reported in this paper, the probabilities, therefore, are that two out of every five samples of sedimentary rock are unsound as determined by the sodium sulphate test.

Although the accelerated sodium sulphate soundness test is used to indicate the possibility of failure through frost action, it does not follow that failure

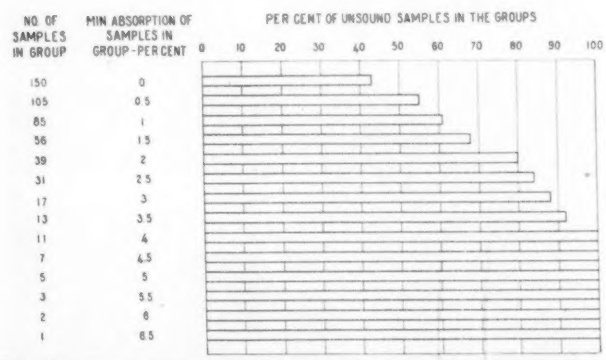

Fig. 5.—Proportion of Unsoundness in Groups of Samples Having Various Minimum Percentages of Absorption

from freezing and thawing is always associated with unsoundness as indicated by the test. Many rocks which are seriously affected by the accelerated soundness test have been successfully used in concrete pavements and structures exposed to frost action for years.

The durability of concrete in which unsound rock was used may result from the quality of the concrete and in spite of the quality of the aggregates. A thoroughly water-tight concrete would certainly delay and possibly entirely prevent disintegration by frost action of an unsound rock used as the coarse aggregate. It is apparent that for durable concrete not only the soundness of the ingredient materials should be considered, but also the character of the concrete itself. A discussion of the soundness of concrete is not within the scope of this paper; but as the character of concrete

is variable and subject to many conditions which may affect the quality, every effort should be made to control these factors. For this reason, the use of aggregates of unquestioned durability or soundness is important. In this connection, the accelerated sodium sulphate soundness test is of value in indicating questionable aggregates. Samples which show unfavorable results with this test should be further investigated by inspection of exposed ledges or faces of the stone at the quarry, or of concrete made of the rock, if it has been previously used, before a final decision is made.

The high percentage of possible failure indicated above shows that great care should be exercised in the selection of sedimentary rock for use in concrete.

These results seem to indicate that, when time is limited, some idea of the relative behavior in the sodium sulphate soundness test of several otherwise comparable materials may be obtained from the absorption test, the highest values indicating the greatest probabilities of failure in the other test.

TABLE 1.—*Results of soundness test and absorption test grouped by kinds of rock and arranged in order of the percentage of absorption*

Sample No.	Location	Name	Soundness test	Absorption per cent
1	New York	Limestone	Sound	0.02
2	Maryland	do	do	.03
3	New York	do	do	.04
4	South Dakota	do	do	.05
5	Tennessee	do	Unsound	.07
6	Maryland	do	Sound	.09
7	Texas	do	do	.11
8	do	do	do	.14
9	West Virginia	do	do	.14
10	Pennsylvania	do	do	.15
11	New York	do	do	.16
12	do	do	do	.17
13	Oklahoma	do	Unsound	.17
14	New York	do	Sound	.18
15	do	do	do	.30
16	Tennessee	do	Unsound	.33
17	Ohio	do	Sound	.34
18	Florida	do	do	.52
19	Texas	do	do	.76
20	do	do	do	.77
21	Ohio	do	Unsound	.87
22	Florida	do	do	.94
23	Texas	do	do	.98
24	Indiana	do	do	1.05
25	Texas	do	do	1.10
26	Florida	do	do	1.11
27	Texas	do	Sound	1.44
28	do	do	do	1.45
29	Ohio	do	Unsound	1.68
30	Alabama	do	Sound	1.70
31	Ohio	do	Unsound	2.01
32	do	do	Sound	2.54
33	do	do	Unsound	2.65
34	Florida	do	do	3.03
35	Texas	do	do	4.12
36	West Virginia	Argillaceous limestone	Sound	.11
37	Texas	do	Unsound	.40
38	do	do	do	.52
39	Ohio	do	Sound	.59
40	Minnesota	do	Unsound	1.35
41	Texas	do	do	1.47
42	do	do	do	2.64
43	Oklahoma	do	do	2.98
44	Texas	do	do	3.36
45	Oklahoma	do	do	3.64
46	Kansas	do	do	4.06
47	do	do	do	4.21
48	do	do	do	4.85
49	do	do	do	5.20
50	Texas	do	do	5.32
51	Kansas	do	do	5.61
52	do	do	do	6.45
53	Maryland	Siliceous limestone	Sound	.02
54	do	do	do	.09
55	do	do	do	.12
56	Kansas	do	do	.15
57	Pennsylvania	do	do	.24
58	Texas	do	do	.37

TABLE 1.—*Results of soundness test and absorption test grouped by kinds of rock and arranged in order of the percentage of absorption*—Continued

Sample No.	Location	Name	Soundness test	Absorption per cent
59	Louisiana	Siliceous limestone	Unsound	1.06
60	Illinois	do	do	1.71
61	Kansas	do	do	2.71
62	Illinois	do	do	2.72
63	do	do	do	2.91
64	Ohio	Dolomitic limestone	Sound	1.40
65	do	do	do	2.86
66	Rhode Island	do	Unsound	4.58
67	Missouri	Crystalline limestone	Sound	.42
68	Ohio	do	Unsound	.46
69	Texas	do	Sound	.99
70	New York	Cherty limestone	do	.08
71	do	do	do	.08
72	Illinois	do	Unsound	1.90
73	Maryland	Marble	Sound	.11
74	Louisiana	do	Unsound	.29
75	New York	Dolomitic marble	Sound	.20
76	Texas	do	do	.23
77	West Virginia	Dolomite	do	.02
78	New York	do	do	.04
79	do	do	do	.05
80	Virginia	do	do	.06
81	Pennsylvania	do	do	.14
82	New York	do	do	.21
83	Michigan	do	do	.39
84	Ohio	do	do	.39
85	do	do	do	.41
86	do	do	do	.49
87	do	do	do	.58
88	do	do	do	.64
89	do	do	do	.69
90	do	do	Unsound	.72
91	do	do	Sound	.77
92	South Dakota	do	do	.83
93	Ohio	do	do	.86
94	do	do	do	1.03
95	do	do	do	1.08
96	do	do	do	1.08
97	do	do	Unsound	1.14
98	do	do	Sound	1.19
99	do	do	do	1.27
100	do	do	do	1.27
101	do	do	do	1.28
102	Wyoming	do	do	1.32
103	Illinois	do	Unsound	1.35
104	Ohio	do	Sound	1.36
105	do	do	do	1.36
106	do	do	Unsound	1.40
107	do	do	do	1.47
108	do	do	Sound	1.52
109	do	do	do	1.59
110	Indiana	do	Unsound	1.66
111	Ohio	do	Sound	1.76
112	do	do	do	1.77
113	do	do	do	1.87
114	Indiana	do	Unsound	2.13
115	Ohio	do	Sound	2.41
116	do	do	do	2.46
117	Michigan	do	Unsound	2.84
118	Ohio	do	Sound	2.88
119	do	do	Unsound	3.37
120	do	do	Sound	3.44
121	do	do	do	3.71
122	do	do	Unsound	6.95
123	do	Argillaceous dolomite	do	.84
124	do	do	do	1.25
125	do	do	do	1.26
126	Indiana	do	do	1.55
127	do	do	do	1.81
128	Arkansas	do	do	2.15
129	Indiana	do	do	2.28
130	do	do	do	2.73
131	do	do	do	2.80
132	Virginia	Siliceous dolomite	Sound	.09
133	Michigan	do	Unsound	2.24
134	Arkansas	Sandstone	Sound	.69
135	do	do	Unsound	1.13
136	do	do	Sound	1.63
137	New York	do	Unsound	1.70
138	Kentucky	do	Sound	1.81
139	Arkansas	do	do	1.93
140	Kentucky	do	do	2.00
141	Minnesota	do	Unsound	4.34
142	Arkansas	Feldspathic sandstone	Sound	.79
143	New York	do	do	1.00
144	Arkansas	do	do	1.10
145	do	do	do	1.43
146	Kentucky	do	Unsound	2.21
147	do	do	do	2.65
148	do	do	do	2.86
149	Mexico	Calcareous sandstone	Sound	.15
150	New Mexico	do	Unsound	1.15

(Continued on page 229)

INSTRUMENT DEVELOPED FOR MEASURING LENGTH OF CRACKS IN CONCRETE

Reported by H. L. BOSLEY, Assistant Materials Engineer, United States Bureau of Public Roads

AN INSTRUMENT for use in measuring the length of cracks in concrete pavements and with which measurements can be made rapidly and with a satisfactory degree of accuracy has recently been designed by the Division of Tests of the Bureau of Public Roads. The instrument was made for use on concrete surfaces in making condition surveys in connection with subgrade studies and to determine the effect of various features of design.

It is thought that a description of the instrument may be of interest to State highway organizations and other agencies who are making condition surveys. Such a study of concrete pavements usually begins with a determination of the amount of cracking which has occurred, and if carefully done with a tape involves considerable painstaking labor.

The apparatus, which embodies the same principle as the chartometer used for measuring distances on maps, consists of a wheel which is rolled along the surface to be measured by means of an operating handle. The circumference of the wheel being known, it is so geared to a revolution counter that for each linear foot of travel one unit is recorded on the counter. Thus, the reading on the counter at any time shows the total distance over which the wheel has been rolled.

Before giving a detailed description of the device, a general view of which is shown in Figure 1, it may be well to discuss its usefulness. One man with the instrument can replace two men with a tape and obtain the same data more easily and it is believed more accurately. A second advantage is that the actual length of meandering cracks can be accurately measured, something which can not readily be done with a tape. Calibration tests with one of these devices indicated that lengths

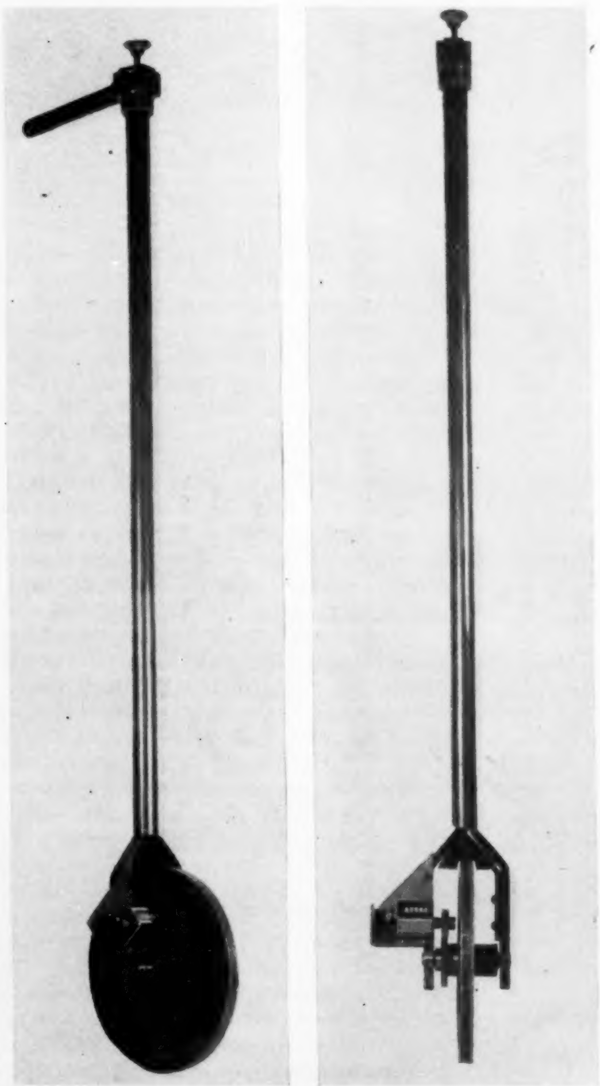

FIG. 1.—TWO VIEWS OF APPARATUS USED IN MAKING SURVEYS

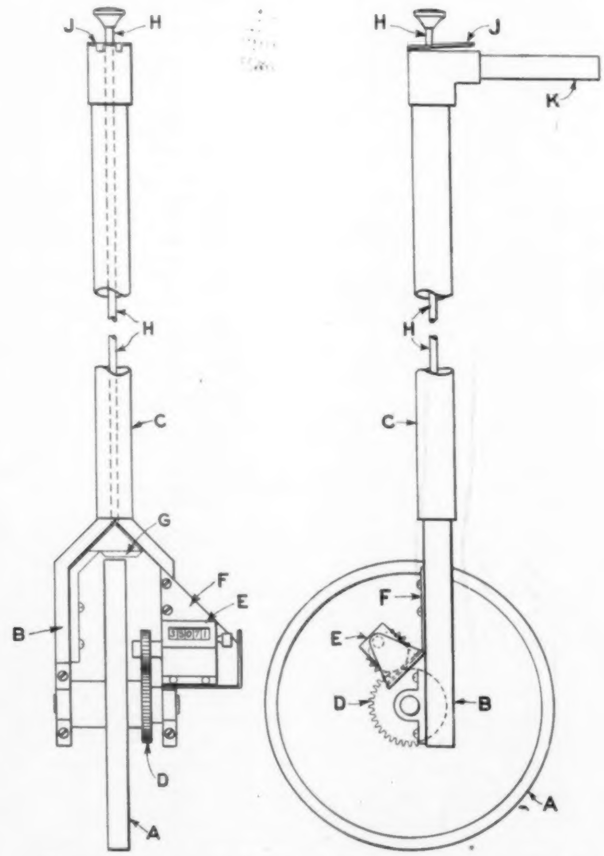

FIG. 2.—DRAWING SHOWING DETAILS OF APPARATUS

measured at the speed of a man walking were accurate to within 0.25 per cent or 1 foot in 400. A check on the individual measurements is available at all times in the total on the counter which will record nearly 20 miles before clearing.

The details of construction are shown in Figure 2. A steel wheel, A, whose circumference is exactly 2 feet, rolls freely in bearings supported by the forked frame, B, attached to the tubular handle, C. A pair of spur gears, D, rotate the spindle of the revolution counter, E, twice for each revolution of the measuring wheel, A. Thus for each distance of 1 foot traversed one unit is registered on the counter. The counter, E, is supported and protected by a guard bracket, F. In transporting the apparatus from one place to another it is desirable to prevent rotation of the counter spindle. For this purpose a rubber brake shoe, G, is provided and this is pressed against the measuring wheel, A, by the rod, H, which terminates in a knob at the end of the operating handle. The operator simply presses down on this knob and locks the wheel, the brake being held in contact by the latch, J. To release the brake a slight pressure on the end of the latch, J, frees the rod, H, and permits the wheel, A, to again roll freely.

The operation in the field is so simple and obvious that it needs no description.

(Continued from page 224)

State-aid routes. The highways classified include, therefore, all routes which carry any considerable volume of present and expected future traffic. The traffic classification for each section is shown in the full report.

The mileage so classified in each of the classification groups is shown in Table 14.

TABLE 14.—*Traffic classification of Vermont highways* [1]

Traffic classification	Miles	Per cent of total miles
Major 1	49.1	2.2
Major 2	129.5	5.9
Total major	178.6	8.1
Medium 1	88.9	4.1
Medium 2	84.1	3.8
Medium 3	342.7	15.6
Total medium	515.7	23.5
Minor 1	215.1	9.8
Minor 2	1,284.4	58.6
Total minor	1,499.5	68.4
Total all routes	2,193.8	100.0

[1] Highways classified include all routes carrying any appreciable density of traffic in 1926.

IMPROVEMENT PLAN PRESENTED

The full report presents a proposed plan of improvement, based upon the analysis of the Vermont Federal-aid highway system,[8] considering present improvements and traffic, shows that 275.5 miles of new construction superior to gravel surfaces will be necessary to meet traffic requirements during the five-year period from January 1, 1927, to December 31, 1931.

[8] The Vermont plan of highway improvement is limited to the Federal-aid system since less than 20 miles not included in the Federal-aid system carried sufficient traffic to justify their inclusion in the five-year plan of improvement.

The cost of improving these highways with surfaces adequate to serve present and expected future traffic as estimated by the Vermont State Highway Department will be approximately $12,000,000. This estimate includes the cost of bridges and structures, grading, and surface costs.

By 1931, because of the normal increase in traffic, 278.5 additional miles of Federal-aid highways are expected to carry 800 or more vehicles and will require surfaces superior to gravel. To serve the traffic on these routes adequately, construction of surfaces superior to gravel on this mileage will be required between 1932 and 1936. Since the major part of this mileage will be on medium traffic routes, the total cost of improving the 278.5 miles included in this group should be considerably less than the required expenditures during the period 1927 to 1931. This decrease, however, will be partially offset by the need for improvement of a comparatively small mileage of routes, approximately 80 miles, not included in the Federal-aid system, with surfaces superior to gravel between 1926 and 1936.

It is believed that a construction program more limited in scope than the proposed five-year program will result in increased total highway expenditures, because of the higher maintenance costs which may be expected to result from postponement of adequate improvement; and that it will also result in inadequate highway service and increased motor-vehicle operating costs.

For the most economical accomplishment of the proposed improvement plan it is recommended that substantially the present Federal-aid highway system be established as a primary or State highway system under the jurisdiction of the State highway department as to construction, maintenance, and control.

It is also recommended that a secondary highway system be established. This system should include the more important traffic routes not included in the primary system.

The establishment of these systems and their improvement in accordance with the foregoing plan will insure a systematic and scientific development of Vermont State highways.

(Continued from page 227)

TABLE 2.—*Geographical distribution of test samples*

State or country	Limestone	Dolomite	Sandstone	Marble	Total
Alabama	1				1
Arkansas		1	7		8
Florida	4				4
Illinois	4	1			5
Indiana	1	7			8
Kansas	8				8
Kentucky			5		5
Louisiana	1			1	2
Maryland	5			1	6
Michigan		3			3
Minnesota	1		1		2
Missouri	1				1
New Mexico			1		1
New York	8	3	2	1	14
Ohio	10	36			46
Oklahoma	3				3
Pennsylvania	2	1			3
Rhode Island	1				1
South Dakota	1	1			2
Tennessee	2				2
Texas	17			1	18
Virginia		2			2
West Virginia	2	1			3
Wyoming		1			1
Mexico			1		1

YADKIN RIVER BRIDGE TEST COMPLETED

Tests of the reinforced concrete arch bridge over the Yadkin River between Albemarle and Mount Gilead, N. C.—involving the structure as it stood in service and with the continuity of the superstructure destroyed—were completed early in December.

The purpose of the stress measurements was to determine the manner in which a full-sized concrete arch, built under normal conditions, deforms under determinate loads, and to compare these deformations and the stresses produced in the arch rib with the deformations and stresses as computed by the generally accepted elastic theory of arches and those derived from the tests of models by means of Beggs deformeter gauges.

Loads have been imposed by means of tanks of water placed on the span. These tanks are made of wood,

Yadkin River Bridge to be Tested to Destruction

12 by 20 by 18 feet inside dimensions, and weigh, when full, 160 tons each.

Data has been secured with the following conditions of loading:

1. A complete series of loads on the bridge as it stood originally; using one loading tank.
2. A complete series of loads on the bridge with the continuity of the superstructure destroyed, so as to approach as near as possible to the conditions generally assumed in designing arches; using one loading tank.
3. With the continuity of the bridge destroyed, loading it in the most critical positions, with two tanks.

The tanks were weighed by means of the deformation of supporting copper cylinders set in steel cylinders and receiving the load from closely fitting pistons. Specially annealed copper cylinders (one-half inch by one-half inch) accurately shaped were placed in the cells so that they carry the entire weight of the tank placed on the pistons. The weight, a function of the deformation of the copper cylinders, was taken from calibration curves previously determined in the laboratory. By this means the empty-tank weight of 47,000 pounds was checked within 300 pounds of the computed weight and other check measurements.

The following measurements were made with various positions of load and three increments of water for each position:

1. The deformation of the concrete and steel at 24 points on the arch rib. From these measurements the stress is determined by the use of the modulus of elasticity derived from tests of specimens taken from the bridge.

The deformation was measured by electric telemeters which are designed on the principle that the electrical resistance of a carbon pile varies with the pressure on the pile. The instrument was attached to steel plugs grouted in the concrete arch rib so that the deformation movements are transmitted as pressures upon the carbon piles. The telemeters are read to one ten-thousandth of an inch and estimated to one hundred-thousandth of an inch.

2. The angular rotation of the arch ring at nine points.

This measurement was made by means of a clinometer, consisting of a steel bar carrying a level bubble and leveling screw attached to a dial reading to one-thousandth of an inch. The instrument was placed and leveled on gauge points located 20 inches apart on steel plugs in the arch rib. The relative displacement of the gauge points was measured, and from these measurements the angular rotation under any increment of load is derived directly.

3. The change in length of middle ordinates of 5-foot arcs of the axis at 5-foot intervals over the entire length of the arch rib.

The middle-ordinate changes were measured by means of a radius meter. This instrument consists of a steel bar 5 feet long, carrying at its center a Federal dial reading to one ten-thousandth of an inch. Gauge points at the ends of the radius meter are placed on corresponding points on steel plugs in the arch and the stem of the dial was allowed to rest on the surface of a square steel plug halfway between the gauge points. The movements of the square plug are transferred to the needle and read on the dial.

4. Deflections at each spandrel point of the arch.

The deflections were measured from a wire suspended over a pulley with a counterweight at one end to maintain a constant tension and sag. Points were located in the concrete at the top of each spandrel column and the deflections measured from these points to the wire.

5. Rotation of the piers at the end of the span under observation.

The pier rotations were measured by clinometers in the same manner as the axial rotations, the gauge points being placed on the top of each pier. These rotation measurements were checked by means of two wires placed 5 feet apart vertically and suspended independently of the span under observation. Movements were shown by the relative longitudinal displacements of fixed points on the wires and on the ends of the piers. Although the field work is now complete it will be several months before the data can be completely analyzed and conclusions reached.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS

Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1924.
Report of the Chief of the Bureau of Public Roads, 1925.
Report of the Chief of the Bureau of Public Roads, 1927.

DEPARTMENT BULLETINS

No. 105D. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
*136D. Highway Bonds. 20c.
220D. Road Models.
257D. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*314D. Methods for the Examination of Bituminous Road Materials. 10c.
*347D. Methods for the Determination of the Physical Properties of Road-Building Rock. 10c.
*370D. The Results of Physical Tests of Road-Building Rock. 15c.
386D. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
387D. Public Road Mileage and Revenues in the Southern States, 1914.
388D. Public Road Mileage and Revenues in the New England States, 1914.
390D. Public Road Mileage and Revenues in the United States, 1914. A Summary.
407D. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
*463D. Earth, sand-clay and gravel. 15c.
*532D. The Expansion and Contraction of Concrete and Concrete Roads. 10c.
*537D. The Results of Physical Tests of Road-Building Rock in 1916, Including all Compression Tests. 5c.
*583D. Reports on Experimental Convict Road Camp, Fulton County, Ga. 25c.
*660D. Highway Cost Keeping. 10c.
*670D. The Results of Physical Tests of Road-Building Rock in 1916 and 1917. 5c.
*691D. Typical Specifications for Bituminous Road Materials. 10c.
*724D. Drainage Methods and Foundations for County Roads. 20c.
*1077D. Portland Cement Concrete Roads. 15c.

DEPARTMENT BULLETINS—Continued

No. *1132D. The Results of Physical Tests of Road-Building Rock from 1916 to 1921, Inclusive. 10c.
1259D. Standard Specifications for Steel Highway Bridges, adopted by the American Association of State Highway Officials and approved by the Secretary of Agriculture for use in connection with Federal-aid road work.
1279D. Rural Highway Mileage, Income, and Expenditures, 1921 and 1922.
1486D. Highway Bridge Location.

DEPARTMENT CIRCULARS

No. 94C. T. N. T. as a Blasting Explosive.
331C. Standard Specifications for Corrugated Metal Pipe Culverts.

MISCELLANEOUS CIRCULARS

No. 62M. Standards Governing Plans, Specifications, Contract Forms, and Estimates for Federal Aid Highway Projects.
93M. Direct Production Costs of Broken Stone.
105M. Federal Legislation Providing for Federal Aid in Highway Construction and the Construction of National Forest Roads and Trails.

FARMERS' BULLETINS

No. *338F. Macadam Roads. 5c.
*505F. Benefits of Improved Roads. 5c.

SEPARATE REPRINTS FROM THE YEARBOOK

No. *739Y. Federal Aid to Highways, 1917. 5c.
*849Y. Roads. 5c.
914Y. Highways and Highway Transportation.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH

Vol. 5, No. 17, D- 2. Effect of Controllable Variables upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D- 3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 24, D- 6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D- 8. Tests of Three Large-Sized Reinforced-Concrete Slabs Under Concentrated Loading.
Vol. 11, No. 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

*Department supply exhausted.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

STATUS OF FEDERAL AID HIGHWAY CONSTRUCTION

AS OF

NOVEMBER 30, 1927

STATES	FISCAL YEARS 1917-1927			FISCAL YEAR 1928		
	PROJECTS COMPLETED PRIOR TO JULY 1, 1927			PROJECTS COMPLETED SINCE JUNE 30, 1927		
	TOTAL COST	FEDERAL AID	MILES	TOTAL COST	FEDERAL AID	MILES
Alabama	$ 20,061,371.68	$ 9,615,099.94	1,400.2	$ 126,805.80	$ 61,582.01	1.9
Arizona	11,809,950.70	6,447,169.27	800.8	267,759.35	192,918.61	14.1
Arkansas	22,337,014.63	9,525,192.75	1,560.6	52,245.29	26,122.64	0.1
California	35,128,269.04	16,967,026.82	1,306.3	2,553,427.98	1,126,574.13	63.0
Colorado	15,497,121.91	7,934,298.91	829.0	91,935.74	48,486.64	0.9
Connecticut	6,397,392.29	2,444,000.54	137.3	1,324,934.52	355,348.84	17.7
Delaware	6,237,026.55	2,345,572.42	159.5	263,662.17	120,820.22	14.6
Florida	7,476,856.31	3,627,912.60	245.1	1,517,818.43	734,206.79	32.7
Georgia	31,951,436.50	15,101,232.40	2,173.6	4,589,628.78	2,170,968.68	209.2
Idaho	13,225,515.45	7,075,527.16	835.5	973,836.68	633,475.61	91.3
Illinois	48,538,982.16	22,781,516.60	1,530.8	408,484.92	191,977.92	15.0
Indiana	23,372,717.74	11,238,568.20	732.5	449,555.13	211,986.95	13.3
Iowa	34,306,138.86	14,395,603.75	2,484.4	1,739,474.81	845,094.32	168.2
Kansas	37,442,061.61	14,730,829.48	1,495.2	1,211,448.88	559,497.95	57.3
Kentucky	23,216,500.53	9,510,694.75	874.9	683,873.69	323,644.21	32.3
Louisiana	15,877,552.20	7,093,892.21	1,178.7	931,554.63	442,316.21	37.9
Maine	10,564,800.06	4,858,452.67	357.6	1,098,204.92	443,485.16	40.5
Maryland	11,790,203.93	5,524,938.27	477.8			
Massachusetts	20,670,246.02	7,425,928.15	410.4	773,728.83	158,264.74	9.6
Michigan	31,977,248.37	14,328,484.99	1,084.2	1,236,846.89	572,143.94	57.7
Minnesota	45,099,648.47	19,046,145.67	3,643.5	3,993,017.05	1,412,498.90	155.9
Mississippi	18,331,230.75	9,004,294.62	1,314.1	1,220,094.38	604,408.40	74.5
Missouri	42,389,290.41	19,681,026.48	1,944.8	2,660,145.75	1,114,666.86	89.3
Montana	12,854,995.72	7,287,288.69	1,151.6	371,852.66	285,259.38	50.5
Nebraska	16,157,040.25	7,739,386.39	2,246.6	2,552,969.23	1,229,026.64	243.6
Nevada	10,421,349.31	7,589,168.68	853.6	321,310.62	279,265.42	52.8
New Hampshire	5,868,897.76	2,778,928.06	264.8	211,962.88	101,807.91	7.0
New Jersey	22,228,240.08	7,495,364.48	316.3	2,467,874.39	593,910.00	39.6
New Mexico	13,336,250.94	7,937,598.06	1,505.2	551,280.81	341,073.59	45.5
New York	54,183,085.44	21,693,955.65	1,439.3	2,833,004.65	909,807.84	61.8
North Carolina	35,295,849.21	14,518,903.18	1,460.1	1,568,316.60	729,783.35	63.3
North Dakota	15,881,558.55	7,746,293.68	2,715.6	2,510,498.95	1,457,967.40	280.4
Ohio	52,621,391.49	19,331,376.76	1,515.0	1,585,695.06	694,089.22	51.6
Oklahoma	30,381,957.08	14,117,589.21	1,268.1	789,742.25	379,754.99	9.6
Oregon	19,583,584.76	10,041,452.94	1,055.0	224,521.65	121,684.57	1.8
Pennsylvania	77,726,174.22	26,317,620.32	1,534.3	2,593,226.73	800,092.96	59.6
Rhode Island	5,233,413.38	1,998,479.06	115.0	700,482.52	227,206.00	15.1
South Carolina	17,002,039.93	7,526,988.80	1,568.4	1,696,816.12	808,011.50	41.7
South Dakota	19,262,063.24	9,507,525.54	2,502.9	277,881.18	149,526.87	56.1
Tennessee	24,283,035.03	11,551,457.55	868.7	1,654,819.20	734,304.01	31.7
Texas	78,190,246.37	31,566,960.45	5,466.4	6,393,551.28	2,876,010.13	241.1
Utah	9,154,377.33	5,767,079.95	628.9	528,149.58	388,851.41	40.2
Vermont	5,037,118.23	2,348,856.01	152.7	1,308,858.37	530,343.92	26.5
Virginia	26,844,025.24	12,537,14[illegible].25	1.188.9	455,975.42	202,124.28	14.0
Washington	18,184,505.97	8,246,551.95	711.1	847,151.85	415,736.32	5.3
West Virginia	10,424,847.32	4,573,748.01	419.4			
Wisconsin	27,891,502.16	11,847,858.90	1,729.5	2,794,079.46	1,371,637.81	134.8
Wyoming	12,650,712.15	7,139,267.05	1,315.9	230,270.61	149,562.10	24.2
Hawaii	343,854.15	97,440.00	6.5	160,636.91	70,440.00	4.7
TOTALS	1,154,740,601.48	510,007,691.24	60,957.6	63,889,413.60	28,197,766.34	2,799.5

STATES	FISCAL YEAR 1928						BALANCE OF FEDERAL AID FUND AVAILABLE FOR NEW PROJECTS	STATES
	*PROJECTS UNDER CONSTRUCTION			PROJECTS APPROVED FOR CONSTRUCTION				
	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES		
Alabama	$ 9,300,874.90	$ 3,995,072.54	457.7	$ 290,282.98	$ 145,141.47	28.9	$ 2,079,779.04	Alabama
Arizona	1,448,605.72	1,088,686.44	67.8	34,528.88	17,264.44	0.3	2,928,204.24	Arizona
Arkansas	3,873,634.24	1,881,611.81	223.9	753,929.34	177,021.26	7.7	1,273,751.54	Arkansas
California	7,506,092.02	3,461,589.86	156.8	251,941.50	147,766.33	9.5	2,853,294.86	California
Colorado	6,645,361.81	3,249,769.50	285.1	35,740.10	20,057.34	2.9	2,449,719.61	Colorado
Connecticut	5,737,303.87	1,609,650.87	69.6	484,816.75	82,320.00	5.5	315,045.75	Connecticut
Delaware	998,398.73	365,371.18	31.2				7,919.18	Delaware
Florida	8,106,464.00	3,545,343.34	176.3	777,845.42	269,730.00	18.0	807,212.27	Florida
Georgia	6,027,113.97	2,937,945.54	182.4				201,015.38	Georgia
Idaho	2,130,996.90	1,281,122.05	131.8	664,939.54	397,473.70	40.8	107,221.48	Idaho
Illinois	14,907,964.22	7,099,766.97	504.9	2,573,252.62	1,257,728.01	89.7	1,655,637.50	Illinois
Indiana	17,491,140.39	8,386,213.54	534.0	469,700.00	39,800.00	17.0	254,558.31	Indiana
Iowa	14,099,057.85	6,076,493.78	447.5	745,407.49	108,923.66	5.8	104,446.49	Iowa
Kansas	14,648,850.44	5,788,306.08	787.2	819,577.58	307,934.37	53.1	146,375.12	Kansas
Kentucky	10,083,438.90	4,761,977.34	439.8	29,398.61	14,704.30		19,735.40	Kentucky
Louisiana	4,075,881.89	1,850,920.80	147.1	1,367,740.56	683,870.27	29.0	214,716.51	Louisiana
Maine	1,886,416.44	593,027.44	41.0	399,073.01	196,774.91	19.9	1,053,881.82	Maine
Maryland	2,246,508.14	1,025,285.64	104.5				9,952.09	Maryland
Massachusetts	6,742,463.44	1,865,290.01	115.4				1,748,343.10	Massachusetts
Michigan	15,217,405.17	6,814,699.93	400.6	978,644.10	364,117.00	25.4	477,610.14	Michigan
Minnesota	4,890,575.77	1,135,000.00	292.5	391,800.98	6,000.00	13.7	112,876.43	Minnesota
Mississippi	6,462,539.46	3,132,245.45	337.9	238,738.19	119,369.09	18.5	575,579.44	Mississippi
Missouri	8,434,609.07	3,691,765.26	273.8	112,891.83	56,445.91	6.7	647,706.49	Missouri
Montana	3,701,999.68	2,557,065.08	283.6	1,378,789.51	766,162.03	151.1	4,080,608.82	Montana
Nebraska	13,297,872.92	6,551,358.91	1,314.2	339,568.27	318,530.18	64.0	382,070.88	Nebraska
Nevada	1,902,033.36	1,652,888.91	186.1	105,947.54	92,937.17	14.8	129,464.82	Nevada
New Hampshire	1,434,838.85	623,139.51	42.3	70,803.54	28,110.00	1.9	3,131.53	New Hampshire
New Jersey	5,821,652.21	1,312,753.56	85.4				2.96	New Jersey
New Mexico	3,076,115.33	2,417,463.28	219.7	45,267.58	28,713.22	2.3	1,434,300.85	New Mexico
New York	44,047,036.00	10,752,628.95	665.9	5,522,600.00	1,136,302.50	73.3	3,187,717.06	New York
North Carolina	3,296,184.21	1,570,015.52	92.0	34,105.00	16,500.00	0.9	595,359.97	North Carolina
North Dakota	4,855,518.78	2,392,951.09	755.4	474,666.97	221,356.82	111.9	125,041.01	North Dakota
Ohio	13,155,144.28	5,116,214.45	352.4	2,980,302.00	1,157,265.00	66.5	2,195,059.57	Ohio
Oklahoma	4,481,386.92	1,898,633.12	309.8	2,775,484.18	1,395,553.64	154.1	20,147.04	Oklahoma
Oregon	2,500,108.61	1,302,136.77	74.1	125,502.52	72,800.41	3.2	523,474.31	Oregon
Pennsylvania	19,516,873.28	5,911,319.10	370.3	1,907,798.38	597,383.33	39.6	1,048,100.30	Pennsylvania
Rhode Island	970,453.89	253,163.74	16.0	835,421.77	223,783.67	13.9	330,562.53	Rhode Island
South Carolina	8,425,077.75	2,379,544.04	253.6	282,188.76	23,999.94	0.4	117,967.72	South Carolina
South Dakota	4,846,875.83	2,560,847.52	772.7	364,442.34	137,906.07	55.5	31,048.00	South Dakota
Tennessee	9,448,056.70	3,936,524.01	249.3	378,552.21	189,276.10	13.0	483,795.33	Tennessee
Texas	12,427,619.16	5,562,219.05	373.1	4,895,702.72	1,989,532.05	182.7	3,108,981.32	Texas
Utah	2,776,902.77	2,060,667.58	150.1	510,365.98	250,706.94	21.1	198,379.12	Utah
Vermont	2,072,322.11	724,824.03	45.0				30,108.04	Vermont
Virginia	5,378,389.26	2,175,489.34	116.3	26,248.75	8,390.23	0.2	21,080.90	Virginia
Washington	2,918,690.33	1,330,600.00	66.5	1,563,718.52	513,000.00	61.2	771,419.73	Washington
West Virginia	8,341,538.35	3,431,427.28	278.0	282,892.22	137,623.76	9.0	3,347.95	West Virginia
Wisconsin	9,435,952.12	4,188,920.97	328.3				1,900,852.32	Wisconsin
Wyoming	3,171,668.23	2,028,733.03	258.0	105,044.96	67,438.84	24.9	115,641.98	Wyoming
Hawaii	1,624,080.08	491,922.64	25.0				805,975.36	Hawaii
TOTALS	364,896,088.35	150,820,606.85	13,899.9	36,725,663.18	13,785,713.96	1,455.9	41,688,221.61	TOTALS

* Includes projects reported completed (final vouchers not yet paid) totaling: Estimated cost $ 130,266,567.21 Federal aid $ 55,625,438.59 Miles 5,021.1